Studies on the isolation, modification, and application of starch from underutilized *Dioscorea* cultivars of Assam

A thesis submitted in partial fulfilment of the requirements

for the award of the degree of

Doctor of Philosophy

Jinku Bora

Registration No.TZ133530 of 2013

Department of Food Engineering and Technology

Tezpur University, Napaam- 784028

Assam, India

Jan 2023

Chapter 5

Conclusion

Chapter 5

Conclusion

5.1 Salient findings of the study

Various literatures revealed that starches of yams have been comparatively underutilized and underexploited in comparison to the starches from other tubers, roots, cereals, fruits, and even legumes. Lack of adequate information on the structure, function, and potential application of the starches is one of the limiting factors for the industrial application of yam starches. The physicochemical, functional, and pasting qualities of native and modified starches of cultivated *Dioscorea* species from northeast India have not yet been thoroughly studied. Meanwhile, there is no report on the comparative study of HMT and ANN treatments on yam starch, and the effect of moisture levels during these treatments on yam starch. Similarly, reports on hydroxypropylated and cross-linked yam starch are very few, which limits it application. Therefore, to address the issues, a study was designed to investigate the effect of physical and chemical modifications on the physical and functional properties of underutilized yam starches, and evaluate their suitability for developing edible films. Finally, all the above mentioned work of the study or thesis was completed, and the conclusions are depicted in the below sections.

5.1.1 Characterization of flours from underutilized *Dioscorea* species and its utilization in cookies enriched with almond protein isolate

- The nutritional composition, functional properties and pasting properties of the flours from the three yam species *D. esculenta*, *D. alata* (purple yam), and *D. alata* (yellow yam) were analyzed. The yam flours were mixed with 10 % API and were used in the formulation of cookies, The prepared cookies were analyzed for nutritional composition, physical and color properties, and sensory analysis of the cookies were also conducted.
- Native flours of the yam species were not suitable for the preparation of cookie due to lower amount of protein in the flours. Therefore, it has to be enriched with

protein from either plant or animal sources to make dough suitable for baked goods.

- Yam flours had a lower foaming capacity and stability than wheat flours due to low protein content. Addition of almond protein isolate increased the water absorption capacity, oil absorption capacity, foaming capacity, and foam stability, but decreased the bulk density.
- Addition of almond protein isolate to the yam flour increased the pasting temperature and decreased the peak viscosity, hot paste viscosity, final viscosity, breakdown, and setback of the yam flours.
- Although almond protein isolate was added to the yam flours, they showed a lower value of dynamic moduli (G´ and G´´). However, the yam flours of *D. esculenta* and *D. alata* (purple yam) added with 10 % almond protein isolate showed a higher value of elasticity than wheat flour, indicated by lower value of loss tangent (tanδ) during rheological testing of cookie dough.
- The cookies prepared from the blends of yam flour and almond protein showed a lower carbohydrate content, making it suitable to be used in diet for obese and diabetic patients.
- Not much difference in the physical properties (diameter, thickness, and spread ratio) of the cookies prepared from blends of yam flour and almond protein isolate was noticed, compared to control cookies prepared from wheat flour. Meanwhile, the cookies prepared from *D. esculenta* and almond protein isolate showed comparable hardness to that of wheat flour cookies.
- Cookies prepared from *D. alata* flours added with 10 % almond protein isolate showed low consumer acceptability due to bitter taste of the cookies.

5.1.2 Native and physically modified starches of underutilized yam species, and their functional, thermal, pasting, morphological and rheological properties

- After the isolation of starches from the yams, the functional, thermal, pasting, morphological, and rheological properties of native and hydrothermally modified starches from the three yam species were investigated.
- HMT caused a significant decrease in peak viscosity, hot paste viscosity, breakdown, setback, and final viscosity.

- ANN caused a significant decrease in peak viscosity, hot paste viscosity, and breakdown with a significant increase in the setback and final viscosity was observed.
- The consistency coefficient and flow behaviour index of the starch pastes increased after ANN, while a lower consistency coefficient of the starch pastes was noticed after HMT.
- Reduction in G´ and G´´ was observed after HMT indicating a low retrogradation tendency of the starch granules, whereas an increase in G´ and G´´ and decrease in tan δ was observed after ANN indicating a higher retrogradation tendency of the starch granules.
- ANN caused greater increase in slowly digestible and resistant starch with a decrease in rapidly digestible starch than HMT. Hence, in this study, ANN was found to be an effective modification method for the yam starches with increased gel strength.
- HMT modified yam starches can be used in products such as bread, ice-creams, puddings and salad dressing, based on findings of this study.
- ANN modified yam starches can be used in food products like jam, thickeners and as an ingredient in cottage cheese, based on the results of this study.
- The suitability of HMT and ANN modified yam starches for the preparation of edible or biodegradable films could be checked.

5.1.3 Hydroxypropylation and cross-linking of underutilized yam starches and their physical and rheological properties

- The isolated starches from yams were also were chemically modified through hydroxypropylation using propylene oxide and cross-linking using sodium trimetaphosphate (STMP), and their physical and rheological properties were determined.
- SEM micrographs of hydroxypropylated starches showed the presence of some small attachments around the starch granules, indents in the surface of the granules and agglomeration of starch granules. While, the STMP modified starch granules appeared to be rougher and having dents in the surface.
- Hydroxypropylation increased the swelling power and solubility of the starch, while cross-linking decreased the swelling power and solubility.

- Hydroxypropylated and cross-linked starches had a higher and lower paste clarity and freeze thaw stability than those of native starches, respectively.
- Hydroxypropylated starches showed a lower value of consistency coefficient (*k*) and flow behavior index (*n*), while cross-linked starches showed a higher value of consistency coefficient (*k*) and flow behavior index (*n*).
- Both the moduli (G´ and G´´) of hydroxypropylated starch pastes were lower than the moduli of native starch pastes, while a higher value of both the moduli was obtained for cross-linked starches compared to native.

5.1.4 Native and hydrothermally treated yam starch-based edible film incorporated with walnut oil and its coating to study the shelf life of grapes

- Finally, the physically modified starches along with walnut oil were used for the preparation of edible films, and the coatings prepared from film-forming solutions were applied on grapes for shelf-life studies.
- Annealed starch film with walnut oil (A2WF) showed a lower value of moisture content, and swelling index due to higher crystallinity of the film, as evident from XRD analysis.
- Both ANN and HMT starch film with walnut oil were more opaque than native films.
- A new bandwidth with a peak at 1745 cm^{-1} was observed in the FTIR spectra of walnut oil incorporated starch film possibly due to the presence of saturated aldehyde functional groups.
- Annealed starch film with walnut oil showed the lowest value of water vapor permeability (WVP), therefore, might be suitable for various packaging applications.
- Both ANN and HMT starch film-forming solutions with walnut oil, which were applied as coatings on grapes for 15 days storage period, delayed the reduction of weight, TSS, titratable acidity, total phenolic content, and antioxidant activity, and delayed development of anthocyanins which promotes aging of grapes.
- Therefore, ANN modified starch along with oil can enhance the shelf life of grapes, as evident from the results of this study.

5.2 Future scope

- Researches to assess the technological characteristics and the availability of protein or other nutrients in the baked products made from gluten free flours or flours enriched with plant based protein isolates or concentrates are required.
- More molecular insights are needed to analyze the effect of amylose/amylopectin ratio, chain length, and size distribution on the properties of starch granules.
- Further investigations on *in vitro* digestibility of yam starches are required to study the influence of treatment conditions, and physicochemical properties, functional properties, size, shape, and other properties of starch granules on enzyme hydrolysis.
- The suitability of HMT, ANN, hydroxypropylation, and STMP modified yam starches for the preparation of edible or biodegradable films can be envisioned. These films may serve diverse packaging functions, including improved barrier properties, biodegradability, and the potential for active packaging with antimicrobial or antioxidant features.
- Hydroxypropylated starches with lower retrogradation tendency could be used in products like soups, where a high paste clarity and lower retrogradation are desired. Cross-linked starches can be used in products that demand a resistance to processing conditions like high shear, temperature and pH. However, these are the limitations of the present study that can be undertaken for research.